Part Two. Wiring Procedures

CHAPTER 3

Design and Layout

The different wiring systems in common use for civilian and armed-forces construction are often called *cable* and *conduit* systems. Chapters 4 and 5 cover the installation details for each of these systems. Many installation methods and procedures used in the wiring processes are common to all systems. In most wiring installations, the blueprints specify the type of wiring to be installed. If the type of wiring is not specified, the electrician must determine the installation method. In general, the type of wiring used should be similar to that installed in adjacent or nearby buildings. Section I of this chapter describes common wiring methods and procedures, and Section II describes methods for *tactical* or *expedient wiring.*

Section I. Interior Wiring

TYPES OF DISTRIBUTION

The electrical power load in a building cannot be properly circuited until the type and voltage of the central power-distribution system is known. The voltage and the number of wires from the power lines to the buildings are normally shown or specified on the blueprints. However, the electrician should check the voltage and type of distribution at the power-service entrance to every building in which wiring is to be done. This is especially necessary when he is altering or adding circuits. Voltage checks are usually made with an indicating voltmeter at the service-entrance switches or at the distribution load centers. The type of distribution is determined by a visual check of the number of wires entering the building (*Table B-1, page B-1*).

If only two wires enter the building, the service is either DC or single-phase AC. The voltage is determined by an indicating voltmeter. When three wires enter a building from an AC distribution system, the service can be single-phase, three-phase, or two ungrounded conductors and a neutral of a three-phase system (*V-phase*).

If the service is single-phase, two of the conductors are hot, and the third is ground. A voltmeter reading between the two hot conductors will be twice as great as the reading between either hot conductor and the neutral or ground conductor. If the service is three-phase, the voltage between any two of the conductors is the same. Normally, one of the conductors is grounded to establish a ground reference voltage for the system.

A V-phase system is the most common service for TO construction. The distribution system is described below. The voltage between the two hot conductors will be 1.732 times greater than the voltage between either hot conductor and the neutral or ground.

Four-wire distribution denotes three-phase and neutral service. When tested, voltages between the neutral conductor and each of the three conductors should all be the same. The voltage readings between any two of these three wires are similar and should equal the neutral-to-hot wire voltage multiplied by 1.732. Common operating voltages for this type of service are 120 and 208 volts or 277 and 480 volts.

LOAD PER OUTLET

The first step in planning the circuit for any wiring installation is to determine the connected load per outlet. It is best to use volt-amperes as the method of determining electrical needs. This eliminates power-factor considerations. The power needed for each outlet or the load per outlet is used to find the number of circuits. It is also used to find the power needed for the whole building. The load per outlet can be obtained in several different ways.

The most accurate method of determining the load per outlet is to obtain the stated value from the blueprints or specifications. Commonly, the lighting outlets shown on the blueprints are listed in the specifications along with their wattage ratings. If the lights to be used are incandescent, this figure represents the total wattage of the lamp.

When fluorescent lights are specified, the *wattage drain* (also called *load per outlet*) should be increased approximately 20 percent to provide for the ballast load. For example, when the fixture is rated as a two-lamp, 40-watt unit, the actual wattage drain is 80 watts, plus approximately 16 watts for both lamp ballasts, or a total load of 96 watts.

If the specifications are not available, the blueprints in many cases designate the type of equipment to be connected to specific outlets. Though the equipment ultimately used in the outlet may come from a different manufacturer, equipment standards provide the electrician with assurance that the outlets will use approximately the same wattage. If the equipment is available, the nameplate will list the wattage used for ampere drain. If not, *Table 3-1* may be used to obtain the average wattage consumption of electrical appliances.

Table 3-1. Wattage consumption of electrical appliances

Appliance	Average Wattage
Clock	3
Coffeemaker	1,000
Fan, 8-inch	30
Fan, 10-inch	35
Fan, 12-inch	50
Heater (radiant)	1,300
Griddle	450
Grill	600
Hot plate	1,250
Humidifier	500
Iron	1,000
Mixer	200
Phonograph	40
Range	8,000
Refrigerator	500
Radio	100
Soldering iron	200
Television	300
Toaster	1,200
Washing machine	1,200
Water heater	4,500

To provide adequate wiring for systems where the blueprints or specifications do not list any special or appliance loads, the following general rules apply:

- For heavy-duty outlets or mogul-size lamp holders, the load per outlet should be figured at 5 amperes each.
- For all other outlets, both ceiling and wall, the wattage drain (load per outlet) should be computed at 1.5 amperes per outlet.

The total outlet load may also be determined on a watts-per-square-foot basis. In this load-determination method, the floor area of the building to be wired is computed from the outside dimensions of the building. This square-footage area is then multiplied by the standard watts-per-square-foot requirement, based on the type of building to be wired. *Table B-14, page B-15*, lists these constants along with a feeder-demand factor for various types of building occupancies. This table gives planning loads based on lighting and appliance needs. Large appliance loads (those in excess of 5 amperes each) should be added to this standard load figure.

CIRCUITING THE LOAD

If all the power load in a building was connected to a single pair of wires and protected by a single fuse, the entire establishment would be without power in case of a breakdown, a short circuit, or a fuse blowout. In addition, the wires would have to be large enough to handle the entire load and, in some cases, they would be too large to make connections to individual devices. Consequently, the outlets in a building are divided into small groups known as *branch circuits*. These circuits are normally rated in amperes as shown in *Table B-15, page B-15*. This table contains a comparison of the various ampere requirements of the branch circuits with the standard circuit components. Normally, the total load per circuit should not exceed 80 percent of the circuit rating.

The method of circuiting the building load varies with the size of the building and the power load. In a small building with little load, the circuit breakers or fuses are installed at the power-service entrance, and the individual circuits are run from this location. For medium-size buildings with numerous wiring circuits, the fuse box should be located at the center of the building load so that all the branch runs are short, minimizing the voltage drop in the lines. When buildings are large or have the loads concentrated at several remote locations, the ideal circuiting would locate fuse boxes at each load center. It is assumed that the branch circuits would be radially installed at each of these centers to minimize the voltage drops in the runs.

The number of circuits required for adequate wiring can be determined by adding the connected load in watts and dividing the total by the wattage permitted on the size of branch circuit selected. This method should not include special heavy loads such as air conditioners that require separate circuits.

The total wattage is obtained from the sum of the loads of each outlet determined by one of the three methods discussed previously. For example, if 20-ampere, 120-volt circuits are to be used, 80 percent of this rating (16 amperes per circuit) is allowed.

The maximum wattage permitted on each circuit equals 16 times 120, or 1,920 watts. If the total connected load is assumed to be 18,000 watts, 18,000 divided by 1,920 shows that 9.375 circuits are required. Since only whole circuits are allowed, ten 20-ampere circuits should be used to carry the connected load. The number of circuits determined by this method should be the basic minimum. For long-range planning in permanent installations, the best practice requires the addition of several circuits to the minimum required or the installation of the next larger modular-size fusing panel to allow for future wiring additions. If additional circuits are used over the minimum required, the number of outlets per circuit can be reduced, therefore making the electrical installation more efficient. This is true because the voltage drop in the system is reduced, allowing the apparatus to operate more efficiently.

The following industry standards are established to ensure that adequate electrical power, switches, and receptacles are available for modern demands. In TO construction, you may not always meet these standards due to the unavailability of equipment, the time required for installation, or the short period of time facilities will be occupied.

SWITCH OUTLETS

- Wall switches are usually located on the latch side of doorways or the traffic side of arches or other wall openings. They are mounted approximately 48 inches from the floor.
- Areas that have more than one entrance will be equipped with a multiple-control wall switch at each principle entrance, unless this requires placing switches within 10 feet of each other.
- At least one switch-controlled lighting outlet must be provided for each dining area that is combined with another room, such as a breakfast nook. The lighting outlet is normally placed over the probable location of the dining table.
- At least one ceiling light outlet in each major room should be wired for a ceiling fan. This is accomplished by running an extra conductor between the light and the controlling light switch.
- Provide for switched lighting on both sides of mirrors and at least one switched light in the ceiling in bathrooms and dressing rooms.
- Kitchen areas require more lighting than other areas of a house. Plan for switch-controlled lights over the sink, the range hood, the breakfast bar, and general counter-top work space. Mount switches at convenient locations.
- Hallways require a switch at each doorway leading into the hall. Switches should be mounted on the latch side of the doorway.
- Stairways should be provided with at least one switch-controlled lighting outlet. Switches should be located at each landing where a doorway is provided for access.

RECEPTACLE OUTLETS

- Each kitchen, family room, dining room, living room, library, den, bedroom, or similar room will have receptacle outlets every 6 feet and near the ends of walls where possible. Unless otherwise specified, receptacle outlets should be placed approximately 12 inches from the floor.
- Each kitchen, pantry, breakfast room, dining room, or similar room should have two or more 20-amp appliance circuits that serve all receptacle outlets. Outlets in other rooms are not to be connected to these circuits. In kitchens and dining areas, a receptacle outlet will be installed along counter-top space every 4 feet. Counter space separated by a range top, a refrigerator, or a sink is considered a separate counter. Outlets will not be installed in a face-up position in the counter top. Any receptacle outlet within 6 feet of a sink must be protected by a ground-fault circuit interrupter (GFCI).
- Bathrooms will have at least one wall-mounted receptacle outlet at each basin. All receptacles must be protected by a GFCI.
- Install at least one receptacle outlet on the front and one on the back of each building. All receptacle outlets within grade-level access will be protected by a GFCI.

- Laundry areas will be provided with at least one receptacle outlet. If the laundry equipment is located in the basement or the garage, at least one additional receptacle outlet must be provided. The laundry receptacle will be wired for 20-amp service and no other outlets will be connected to this circuit.
- Hallways that are 10 feet long or longer will have at least one receptacle outlet. **NOTE: Hallway length is determined along the centerline without passing through a doorway.**

Motors that are used on portable appliances are normally disconnected from the power source either by removal of the appliance plug from its receptacle or by operation of an attached built-in switch. Some large-horsepower motors, however, require a permanent power installation with special controls. Motor switches *(Figure 3-1)* are rated in horsepower capacity. In a single-motor installation, a separate circuit must be run from the fuse or circuit-breaker panel to the motor, and individual fuses or circuit breakers must be installed.

For multiple motor installations, the National Electrical Safety Code requires that—

> *Two or more motors may be connected to the same branch circuit, protected at not more than 20 amperes at 125 volts or less or 15 amperes at 600 volts or less, if each does not exceed 1 horsepower in rating and each does not have a full load rating in excess of 6 amperes. Two or more motors of any rating, each with individual overcurrent protection (provided integral with the motor start switches or an individual unit), may be connected on one branch circuit if each motor controller and motor-running overcurrent device is approved for group installation, and the branch circuit fusing rating is equal to the rating required for the largest motor plus an amount equal to the sum of the full load ratings of the other motors.*

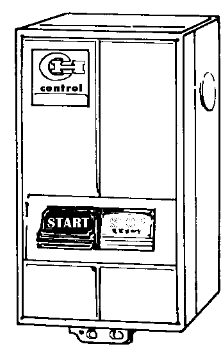


Figure 3-1. Motor switch

BALANCING THE POWER LOAD ON A CIRCUIT

The ideal wiring system is planned so that each wiring circuit will have the same ampere drain at all times. Since this can never be achieved, the circuiting is planned to divide the connected load as evenly as possible. Thus, each circuit uses approximately the average power consumption for the total system to make for minimum service interruption. *Figure 3-2, page 3-6*, demonstrates the advantage of a balanced circuit when using a three-wire, single-phase, 110/220-volt distribution system.

The current used is known as *alternating current* because the current in each wire changes or alternates continually from positive to negative to positive and so on. The change from positive to negative and back again to positive is known as a *cycle*. This usually takes place 60 times every second, and such current is then known as 60-cycle current. Sixty times every second each wire is positive, 60 times every second each wire is negative, and 120 times every second there is no voltage at all on the wire. The voltage is never constant but is always gradually changing from zero to maximum, with the average being about 120 volts. The current in the neutral conductor of a balanced three-wire, single-phase system will remain at zero as a result of the applied AC.

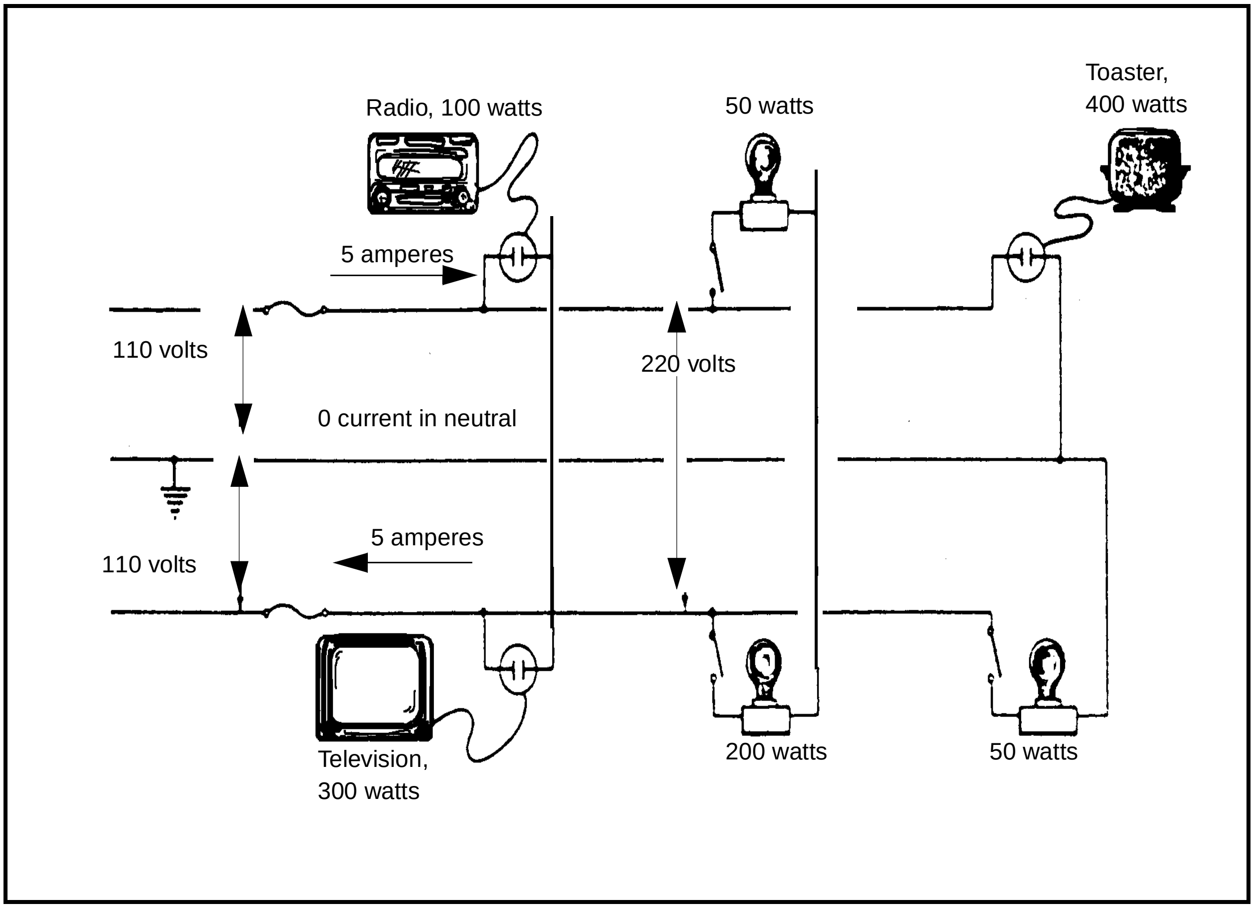


Figure 3-2. Circuit balancing

LOAD PER BUILDING

MAXIMUM DEMAND

In some building installations, the total possible power load may be connected at the same time. In this case, the demand on the power supply (which must be kept available for these buildings) is equal to the connected load. In the majority of building installations where armed-forces personnel work, the maximum load which the system is required to service is much less than the connected load. This power load, which is set at some arbitrary figure below the possible total connected load, is called the *maximum demand* of the building.

DEMAND FACTOR

The ratio of maximum demand to total connected load in a building expressed as a percentage is termed *demand factor*. The determination of building loads can be obtained by using the standard demand factors shown in *Table B-14, page B-15*. For example, if the connected load in a warehouse is 22,500 watts for warehouses, the actual building load can be obtained as follows: 100 percent of the first 12,500 watts equals 12,500; 50 percent of the remaining 10,000 watts equals 5,000; therefore, the total building load is 12,500 plus 5,000 watts, or 17,500 watts.

BALANCING THE POWER LOAD OF A BUILDING

The standard voltage-distribution system from a generating station to individual building installation is the three- or four-wire, three-phase type. Distribution transformers on the power-line poles, which are designed to deliver three-wire, single-phase service, change the voltage to 120 or 240. These transformers are then connected across the distribution phase loads in a balanced arrangement. Consequently, for maximum transformer efficiency, the building loads assumed for power distribution should also be balanced, as previously illustrated in *Figure 3-2*.

WIRE SIZE

Wire sizes No 14 and larger are classified according to their maximum allowable current-carrying capacity based on their physical behavior when subjected to the stress and temperatures of operating conditions. No 14 wire is the smallest wire size permitted in interior wiring systems.

The size of the conductor used in feeder and branch circuits depends on the maximum allowable current-carrying capacity and the voltage drop coincident with each wire size. The size of the conductor for branch circuits (that portion of the wiring system extending beyond the last overcurrent device protecting the circuit) should be such that the voltage drop will not exceed 3 percent to the farthest outlet for power, heating, or lighting loads. The maximum voltage drop for feeders is also 3 percent, provided that the total voltage drop for both feeder and branch circuit does not exceed 5 percent. *Table B-16, page B-16,* which is based on an allowable 3 percent voltage drop, lists the wire sizes required for various distances between supply and load at different amperages. This table may be used for branch circuits originating at the service entrance. This is the common house or small building circuit. Use *Table B-15, page B-15,* to determine the proper wire size

The minimum gauge for service-wire installation is No 8. The service-wire sizes are increased because they must not only meet the voltage-drop requirement but also be inherently strong enough to support their own weight, plus any additional loading caused by climatic conditions such as ice or branches.

GROUNDING AND BONDING

REQUIREMENTS

The neutral conductor must be grounded on all electrical systems if the voltage between the hot lead and the ground is less than 150 volts. In addition, all systems should have a grounded neutral where the voltage to ground does not exceed 300 volts. Interior circuits operating at less than 50 volts need not be grounded if the transformer supplying the circuit is connected to a grounded system.

TYPES OF GROUNDING

A *system ground* is the ground applied to a neutral conductor. It reduces the possibility of fire and shock by reducing the voltage of one of the wires of a system to 0 volts potential above ground.

An *equipment ground* is an additional ground that should be attached to all appliances and machinery. An equipment ground is advantageous because the appliances and machinery can be maintained at zero voltage. Also, if a short circuit occurs in a hot lead, the fuse protection will open the circuit and prevent serious injury to operating personnel.

METHODS OF GROUNDING

A system ground is provided by placing a No 6 copper (or No 4 aluminum) wire between the neutral wire, service box, bonding wire, and a grounding electrode at the building's service entrance. The grounding electrode may be a buried water pipe, the metal frame of a building, a local underground system, or a fabricated device. If more than one electrode is used, they must be placed a minimum of 6 feet apart.

Water Pipe

An underground water piping system will always be used as the grounding electrode if such a piping system is available. If the piping system is less than 10 feet deep, supplemental electrodes will be used. Interior, metallic, cold-water piping systems will always be bonded to the grounding electrode or electrodes.

Plate Electrodes

Each plate electrode will have at least 2 square feet of surface exposed to the soil. Iron or steel electrodes must be at least 1/4 inch thick, and nonferrous metal must be at least 0.06 inch thick. Plates should be buried below the permanent moisture level if possible.

Pipe Electrodes

Clean, metallic pipe or conduit at least 3/4-inch trade size may be used. Each pipe must be driven to a depth of at least 8 feet. If this cannot be done, the electrodes may be buried in a horizontal trench. In this case, the electrode must be at least 8 feet long.

Rod Electrodes

Rod electrodes of steel or iron must be at least 3/8 inch in diameter. Rods of nonferrous material must be at least 1/2 inch in diameter. The standard ground rod for the military is a 5/8-inch steel rod with three sections of 3 feet each. Installation of rod electrodes is the same as for pipe electrodes. *Figure 3-3* shows typical grounding procedures.

GROUND RESISTANCE

Electrodes should have a resistance to ground of 25 ohms or less. Underground piping systems and metal frames of buildings normally have resistance to ground of less than 25 ohms. Resistance to ground of fabricated electrodes will vary greatly depending on the soil and the method of installation. Burying an electrode below the permanent moisture level of the soil normally reduces the resistance to ground to acceptable values. Grounding systems should be tested by using a *Megge*r ground tester. This device may be found in organizations such as the installation's Department of Public Works (DPW) or engineer division.

The voltage between the neutral or grounded conductor of a grounded system and the ground (water pipes, metal frames of buildings, ground rods) should be zero at all times. The detection of any voltage indicates a faulty wiring system.

BONDING

Bonding is a method of providing a continuous, separate electrical circuit between all metallic circuit elements (conduit, boxes, and so forth) and the service-entrance ground. The ground or neutral conductor is attached to the bonding circuit only at the service entrance. At this point, the neutral wire and a bonding wire from the service box are attached to the grounding electrode. All other metallic circuit elements are connected to this grounded point through physical connections of the metallic conduit, armored cable, or flexible metal conduit. Nonmetallic conduit or cable must have a conductor in it to provide this bonding circuit. This conductor should be attached to the metal boxes or fixtures where the nonmetallic cable or conduit terminates.

All metal-to-metal connections must be tight to ensure a continuous bonding circuit. When the electrical continuity of a metal-to-metal connection is doubtful, use a wire jumper between the two metal pieces. As an example, the equipment ground wire of a receptacle (the green wire) is connected to the bonding circuit through the two screws fastening the receptacle to the box. If the box is recessed to obtain a flush receptacle, the connecting screws are not tightened but are used as adjusting screws to properly locate the receptacle. In this case, a wire must be placed between the box and the equipment ground terminal of the receptacle. Proper bonding prevents shocks from metal surfaces of an electrical system.

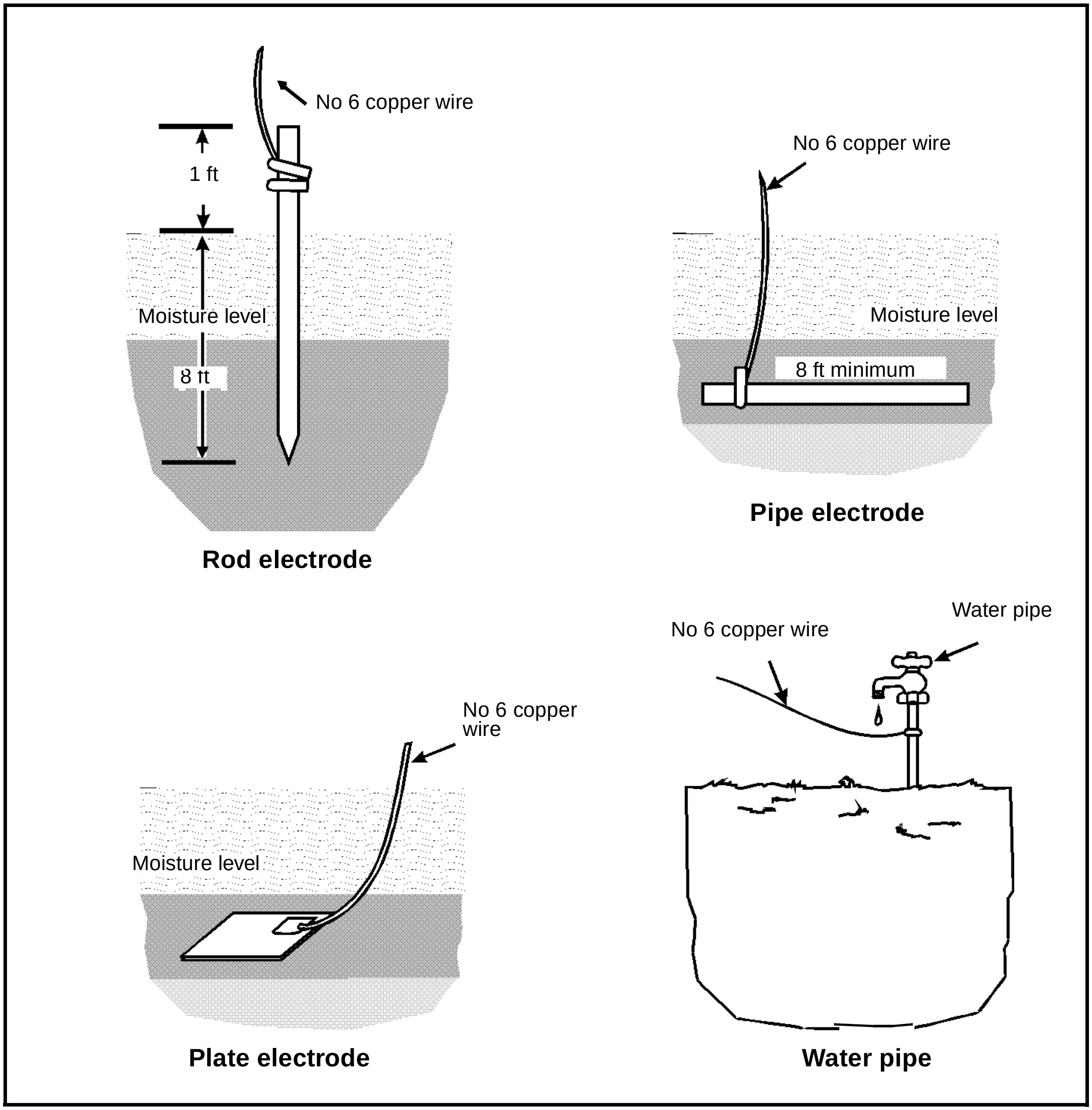


Figure 3-3. Methods of grounding

WIRING FOR HAZARDOUS LOCATIONS

Special materials and procedures must be used to install electrical systems in areas where a spark could cause a fire or an explosion. Typical areas of this type are hospital operating rooms and acetylene storage or production facilities. Hazardous locations are divided into three classes:

CLASS I

Class I includes areas where flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

CLASS II

Class II includes areas where combustible dust is present.

CLASS III

Class III includes areas where easily ignitable fibers or filings are present but are not suspended in the air in sufficient quantities to produce ignitable mixtures.

Each class is further subdivided into two divisions. In division one of each class, the hazardous material is present in free air so that the atmosphere is dangerous. In division two of each class, the hazardous material is in containers, and dangerous mixtures in the air occur only through accidents.

INSTALLATION IN HAZARDOUS LOCATIONS

Detailed information on installation material and procedures must be obtained from theater commands and standard plans. The information below gives general guidance about the type of installation required for each class and division of hazardous locations:

CLASS I

In division one areas, wiring must be in threaded, rigid-metal conduit, with explosion-proof fittings or mineral-insulated, metal-sheathed (Type MI) cable. Division two areas may have flexible metal fittings, flexible metal conduit, or flexible cord that is approved for hard usage. All equipment such as generators, controllers, motors, fuses, and circuit breakers must be enclosed in explosion-proof housings.

CLASS II

In division one areas, wiring must be in threaded rigid conduit or Type MI cable with flexible metal conduit and threaded fittings where necessary. Equipment must be in dustproof cabinets with motors and generators in totally enclosed fan-cooled housings. In division two areas, electrical metallic tubing may also be used.

CLASS III

In division one areas, the same requirements exist as for class I, division one. In division two areas, open wiring is permitted. Motors and generators must be totally enclosed.

INSTALLATION OF SIGNAL EQUIPMENT

Signal equipment may occasionally be supplied for 120-volt operation, in which case it must be installed in the same manner as outlets and sockets operating on this voltage. Most bells and buzzers are rated to operate on 6, 12, 18, or 24 volts AC or DC. They can be installed with minimum consideration for circuit insulation, since there is no danger of shock to personnel or fire due to short circuits. The wire commonly used is insulated with several layers of paraffin-impregnated cotton or a thermoplastic covering. Upon installation, these wires are attached to building members with small insulating staples and are threaded through building construction members without insulators.

BATTERY OPERATION

Early installations of low-voltage signal systems were powered by 6-volt dry cells. For example, two of these batteries were installed in series to service a 12-volt system. If the systems involved a number of signals over a large area, one or more batteries were added in series to offset the voltage drop. Though this type of alarm or announcing system is still being used in some areas, it is a poor method because the batteries used as a power source require periodic replacement.

TRANSFORMER OPERATION

Most present-day buzzer and bell signal systems operate from a transformer power source. The transformers are equipped to be mounted on outlet boxes and are constructed so that the 120-volt primary-winding leads normally extend from the side of the transformer adjacent to the box mounting. These leads are permanently attached to the 120-volt power circuits, and the low-voltage secondary-winding leads of the transformer are connected to the bell circuit (*Figure 3-4*). If more than one buzzer and push button are to be installed, they are paralleled with the first signal installation. A typical wiring schematic diagram for this type of installation is shown in *Figure 3-5*.

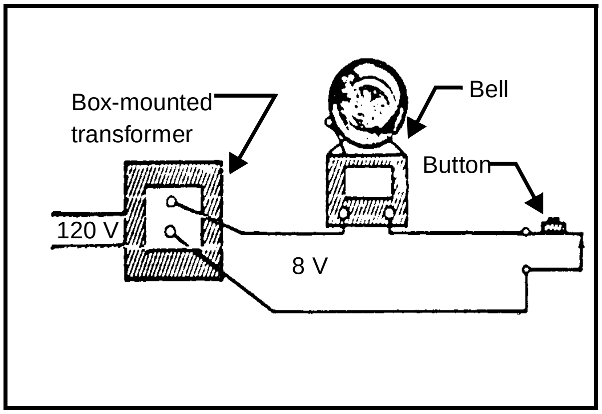


Figure 3-4. Bell and buzzer wiring

SPECIAL SWITCHES

THREE-WAY SWITCHING

A single-throw switch controls a light or a receptacle from only one location. When lights have to be controlled from more than one location, a double-throw, commonly called a *three-way switch*, is used. Three-way switches can be identified by a common terminal that is normally color-coded darker than the other terminals and located alone at the end of the switch housing. A schematic wiring diagram of a three-way switch with a three-wire cable is shown in *Figure 3-6*. In the diagram, terminals A and A^1 are the common terminals, and the switch operation

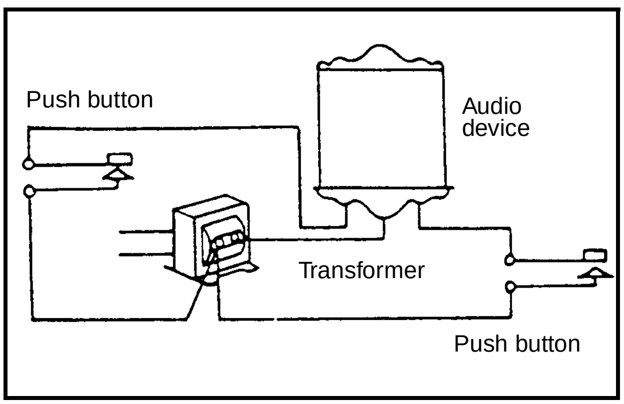


Figure 3-5. Two-push-button system

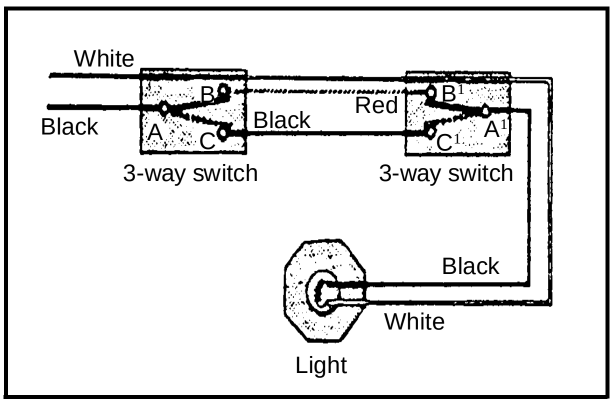


Figure 3-6. Three-way switch wiring

connects them either to B or C and B[1] or C[1], respectively. Either switch will open or close the circuit, turning the lights on or off.

FOUR-WAY SWITCHING

Occasionally, it is necessary to control an outlet or light from more than two locations. Two three-way switches plus a four-way switch will provide control at three locations as shown in *Figure 3-7*. The switches must be installed with the four-way units connected between the two three-way units and the three-wire cable installed between the switches.

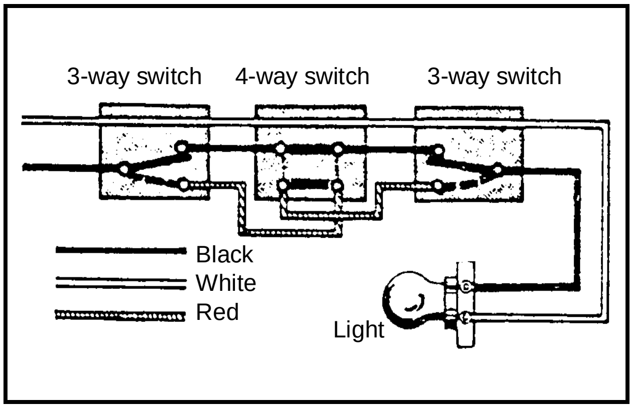


Figure 3-7. Four-way switch wiring

VARIABLE-CONTROL DEVICES

Electrical dimmers provide a full range of light from bright to dim for incandescent lighting. Special electronic dimmers exist for use with florescent lighting. A turn of the dial adjusts the brightness level, and a push-knob switch turns the light on or off without changing the brightness setting (*Figure 3-8*).

Another type of dimmer switch has a high-low control that provides two levels of illumination: full brilliance at the top position and approximately half brilliance at the bottom position. Variable-control devices are also used as speed-control devices that control the speed of tools and equipment using standard AC or DC motors. Some variable-control devices are electronic in nature since their construction uses solid-state circuitry and switches.

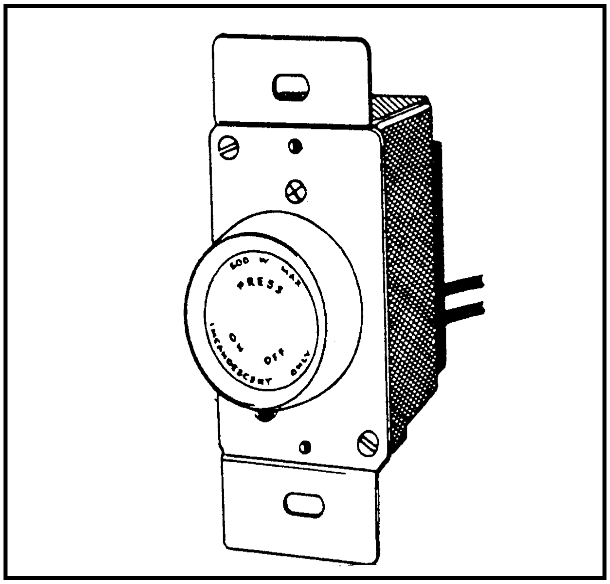


Figure 3-8. Push-pull rotary switch

ADDITIONS TO EXISTING WIRING

CIRCUIT CAPACITY

When installing additions to existing wiring in a building, the electrician first determines the available extra capacity of the present circuits. This can readily be obtained by ascertaining the fused capacity of the building and subtracting the present connected load. If all the outlets do not have connected loads, their average load should be used to obtain the connected load figure. When the existing circuits have available capacity for new outlets and are located near the additional outlet required, they should be extended and connected to the new outlets. Consideration must be given to the additional voltage drop created by extending the circuit. The proper wire size may then be determined.

NEW CIRCUITS

When the existing outlets cannot handle an additional load and a spare circuit has been provided in the local fuse or circuit-breaker panel, a new circuit is installed. This is also done if the new outlet or outlets are so located that a new circuit can be installed more economically than an existing circuit extension. Moreover, the installation of a new circuit will generally decrease the voltage drop on all circuits, resulting in an increase in appliance operating efficiency.

NEW LOAD CENTER

In many wiring installations, no provisions are made for spare circuits in the fuse or breaker panel. Moreover, the location of the new circuit required is often remote from the existing fuse box or circuit-breaker panel. In this case, the preferred method of providing service to the circuit is to install a new load center at a location that is close to the circuit outlets. This installation must not overload the incoming service and service-entrance switch. Should such an overload be indicated, the service equipment should also be changed to suit the new requirements. Sometimes, this can be accomplished in two-wire systems by pulling in an additional wire from the power line. This changes the service from two-wire to three-wire at 120 to 240 volts. In these cases, the fuse box or the circuit-breaker panel should also be changed and enlarged to accommodate the increased circuit capacity.

CIRCUIT DIAGRAMS

Figure 3-9, page 3-14, shows some typical arrangements for switches, fixtures, and receptacles. Although many other combinations are also possible, these drawings should help in planning circuit arrangements. Before you do any wiring, check with the supervisor to find out if there are any specific equipment requirements.

Section II. Expedient Wiring

PURPOSE

In many applications, electrical wiring installations are needed for temporary use. Examples are forward-area installations (tactical wiring), TO, field training exercises (FTXs), and civilian disaster-relief situations in foreign countries and the US. Complete installations of electrical systems would require too much time and be very costly, so they would not be practical.

Wiring situations in the TO could be considered tactical wiring and would require different types of wiring, such as open wiring where wiring systems and devices are exposed on studs, ceilings, and joists. Military light sets are also used in expedient or tactical installations.

WIRE

Wire sizes should be selected according to normal installations. The wire should be laid over the ceiling joist and fastened by nails driven into the joist and bent over the wire. The nails should exert enough force to firmly grip the wire without damaging the insulation. If possible, expedient wiring installations should be fastened to joists or studs at least 7 feet above the floor. This prevents accidental damage to the system or injury to personnel. The wires should be supported in accordance with normal installation.

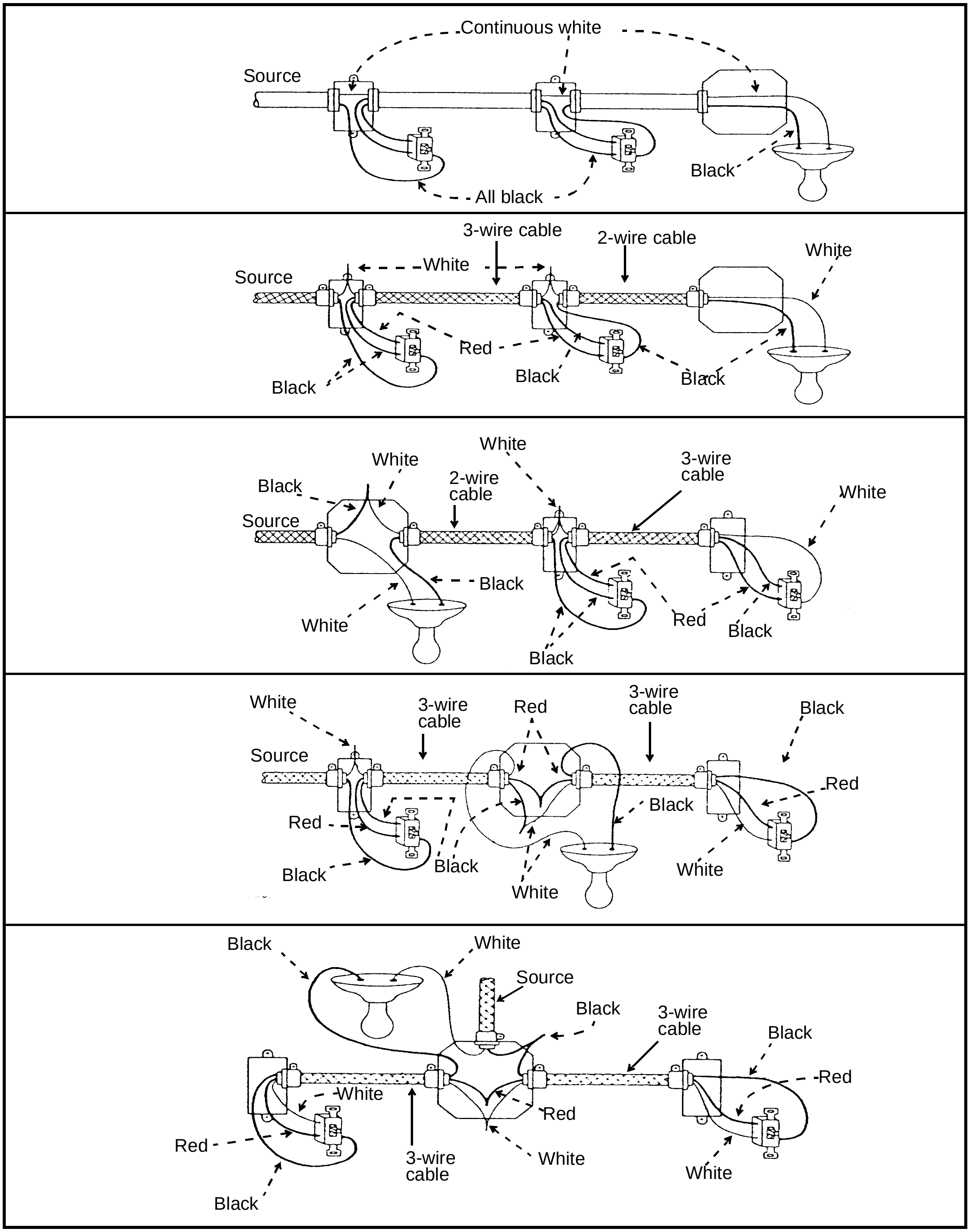


Figure 3-9. Typical wiring combinations

SUPPORTS

JOINTS, SPLICES, TAPS, AND CONNECTIONS

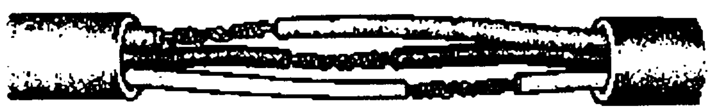
Joints, splices, taps, and connections are made as outlined in Chapter 1. In expedient wiring, use electrical tape as a protective covering on the connection and to provide additional protection where nails are bent over the wire.

FIXTURE DROPS

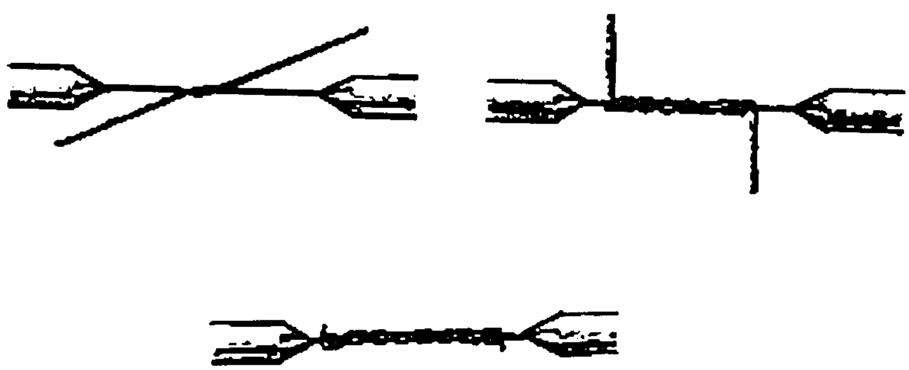
Fixture drops, preferably pigtail splices, are installed by taping their leads to wires and taping the taps. The sockets are supported by the tap wires.

CORDS OR NONMETALLIC-SHEATHED CABLE

Figure 3-10 shows how to tap a two-conductor cord or nonmetallic-sheathed cable in an expedient wiring installation. Remove the outer rubber or sheathing at the point of fixture attachment, and tap the fixture leads to the conductor with a Western Union splice, purposely maintaining the separation between taps as shown. Then, individually tape each tap.



NOTE: Portable cord splices should only be done in an emergency.



How to make a Western Union splice

Figure 3-10. Tapping stranded copper wire